Supplemental Experimental Procedures

Data Collection

Fieldwork was carried out on a colour-ringed population of green woodhoopoes near Morgan's Bay (32°43'S, 28°19'E), Eastern Cape Province, South Africa. Woodhoopoes at the study site inhabit forested valleys, which are separated by open grassland not used by the birds, so territories are arranged linearly along the river courses; the sampled groups all had territories that bordered two others.

Data were collected on self-preening from 10 groups between November 2000 and May 2001. As with self-directed behaviour in various primate species [S1, S2], self-preening in woodhoopoes is a likely indicator of stress levels [S3, S4]. The start and end time of all bouts by identified individuals were recorded throughout observation sessions; bouts were considered finished when no preening had occurred for 30 s [S3].

Data were collected on IGIs and roosting behaviour in three periods (November 1999 – May 2000; November 2000 – May 2001; November 2001 – March 2002) from 12 groups. Since roost choices might be affected by the dominant female roosting alone in the nest cavity during breeding (one attempt per season in the study population [S5]), only data collected during non-breeding periods are considered here. Groups were monitored during the morning for 3–5 h after emergence from their overnight roost; monitoring ceased in the middle of the day when woodhoopoes are less active and IGIs rarely occur (Radford pers. obs.). When identified, the position of the roost was marked on a 1:10,000 orthophotographic map [S6]. The occurrence and duration of any IGIs that the focal group was involved in during the morning session were recorded; the outcome of extended IGIs was also noted (definitions followed refs. [S7, S8]). An IGI was deemed to have occurred if a group responded within 5 min to a chorus from its rival, and was considered finished once no chorus had been given for 5 min. The duration of the IGI was recorded as the time from the start of the first chorus to the end of the last one. If an intruding group spent at least 10 min after the last chorus in the territory of its rival and the resident group moved deeper into its own territory, the former was classified as winning; if the intruding group retreated back to its own territory within 1 min of the final chorus, the resident group was deemed to have won. The few cases where

there was no clear-cut winner (n = 3) – where the intruding group remained on the resident's territory for 1–10 min after the end of the rallying or the resident group did not move deeper into its own territory – were not included in the analyses.

Groups were also monitored for at least 2 h before dusk on the same days to record the occurrence of any additional IGIs and the location of the chosen roost (as above). Also recorded were the time at which the group arrived at the roost site and entered the roost cavity, whether all group members roosted together or split between different roosts, and whether any allopreening occurred prior to roost entry. Allopreening, whereby one group member preens another, is a readily observed affiliative behaviour known to serve a social function in this species [S9].

Data Analysis

Territorial maps of all groups were constructed as part of a previous study [S6]. These were used to calculate the distance of roosts from the nearest territory border and thus determine whether each was located within a zone of conflict (see also [S3]); all 12 groups had between one and three roosts in a zone of conflict. Initial analyses considered differences between groups in the pattern of roost use. For each group, we calculated the expected use of zone-of-conflict roosts (if all available roosts were used equally) by multiplying the total number of roosting occurrences with the proportion of all known roosts that were located within a zone of conflict. We used a Wilcoxon signed-ranks test to compare this expected value against the actual proportion of roosting occurrences that were in a zone of conflict. We used Spearman rank correlations to assess whether the difference between expected and observed usage of zone-of-conflict roosts was related to overall involvement in intergroup conflict, which was calculated both as the proportion of observation time spent engaged in IGIs and the rate of IGI occurrence (as in [S7]).

To assess how IGIs influence stress levels, we considered self-preening bouts from three different periods of the day: the 30 min before the start of a morning IGI; the 30 min immediately after the end of that IGI; and the 30 min at the start of the afternoon observation session (mean ± SE time from end of IGI to start of afternoon observation session = 7.7 ± 1.1 h, range = 3.3 − 10.4 h; n = 58 days). Data from all three sessions in the same day were

recorded for a given group, to allow a repeated-measures analysis. We used mixed-effects models (see below) to examine whether the mean duration of self-preening bouts increased when an IGI occurred, and whether any increase was still apparent later in the day. Day nested within group identity was included as a random factor, to take into account the repeated-measures structure of the data (i.e., that data from the three observation sessions from the same group on the same day are not independent). Data for short and extended IGIs were analysed separately. Qualitatively similar results were obtained when using the rate of self-preening bouts instead of their mean duration (as presented in the main paper), both for short (log-transformed rate data; effect of period: $\chi^2_2 = 1.34$, n = 57, p = 0.512) and extended ($\chi^2_2 = 14.79$, n = 48, p = 0.001) IGIs.

All remaining statistical tests were conducted using individual roosting events as the unit of analysis. We used mixed-effects models (see below) with group identity as a random factor, to take into account the fact that observations of the same group are not independent. Days on which an IGI occurred in the afternoon observation session prior to roost use (n = 25) were not included in analyses, as the aim was to consider lasting responses to conflict (mean ± SE time from analysed IGIs to roosting: 10.7 ±0.5 h, range = 7.2–13.1 h, n = 134 days). For the remaining observation days, we categorised morning sessions as involving: (a) at least one extended IGI; (b) at least one short IGI, but no extended IGI; or (c) no IGIs; the few occurrences (n = 12) of mornings including only an IGI of intermediate duration (5–15 min) were discarded. Relative occurrence of the three session categories (extended, short, none) did not differ significantly between the three data-collection periods (chi-squared test: $\chi^2_4 = 1.44$, n = 232, p = 0.838) or between months ($\chi^2_{12} = 13.72$, n = 232, p = 0.319).

We assessed whether IGI categorisation (extended, short, none) affected the likelihood of roosting in a zone of conflict (n = 232 observations), of changing roost from the previous night (n = 153) and of choosing a roost closer to the shared border when changing roost site from the night before (n = 64). We used further analyses to consider the times of arrival at the roost site and entry into the roost, whether the group split to roost and whether allopreening occurred prior to roost entry. Since these behaviours could be influenced simply by being in a zone of conflict [S3], we confined analyses to days on which groups roosted in the zone of conflict (n = 70). We standardised times by using the number of minutes after (positive values)

or before (negative values) sunset on that day (see [S10]); location-specific predicted values for the time of sunset (when the upper edge of the descending sun is on the horizon) were obtained from the United States Naval Observatory (USNO) data service (http://www.usno.navy.mil/USNO/astronomical-applications/data-services). We conducted additional analyses to consider whether the outcome (win, loss) of extended IGIs affected roost choice (n = 54), arrival time (n = 31) and likelihood of allopreening (n = 31); we did not analyse the effect on group splits because there were very few (n = 2) such occurrences following extended IGIs.

We ran the mixed-effects models using package lme4 version 1.0-6 [S11] in R version 3.0.2 [S12]. We analysed continuous response variables (duration of self-preening bouts; log-transformed rate of self-preening bouts; arrival time at roost; entry time at roost) using linear mixed models (LMMs) with an identity link function. We analysed binary response variables (location of roost; change of roost site; movement of roost site; occurrence of splitting; occurrence of allopreening) as proportions weighted by sample size, using generalised linear mixed models (GLMMs) with a logit link function. To assess the significance of fixed effects – period of observation (before IGI; immediately after IGI; start of afternoon session), IGI categorisation (extended; short; none) and outcome of extended IGIs (win; lose) – we calculated the Wald χ^2 statistic for a comparison between models including and omitting that factor. When IGI categorisation was found to have a significant effect, we conducted post-hoc pairwise comparisons based on unadjusted P values from generalized linear hypothesis tests, using package multcomp version 1.3-2 [S13]. Visual inspection of residual plots confirmed the assumptions of homogeneous variances and normality.

Supplemental References

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